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GENERAL NOTES.

Members and friends of the Society are invited to aid the Committee on Publication in carrying out the work of this department. Communications of general interest will be gladly received, and may be sent to SIDNEY D. TOWNLEY, 2023 Bancroft Way, Berkeley, California.

Mr. JOHN A. BRASHEAR, the well-known optician, has been elected Chancelor of the University of Western Pennsylvania.

CHARLES A. BACON, professor of astronomy in Beloit College, Wisconsin, and director of Smith Observatory, died November 6, 1901.

The report of the Board of Visitors of the United States Naval Observatory has been published in *Science*, December 6th. Extracts from the report of the Superintendent of the Naval Observatory, with some editorial comments, are printed in the issue of the same journal for December 20th.

At the meeting of the Astronomical and Astrophysical Society of America held in Washington, D. C., December 30, 1901, to January 3, 1902, the following officers were elected: President, SIMON NEWCOMB; First Vice-President, G. E. HALE; Second Vice-President, W. W. CAMPBELL; Treasurer, C. L. DOOLITTLE; Councilor, E. C. PICKERING; Councilor, R. S. WOODWARD.

The next meeting of the Society will be held at Washington, in December, 1902.

At a meeting of the National Academy of Sciences at Washington in April, Professor S. P. LANGLEY read a paper reviewing his work in the investigation of the solar spectrum, the paper being a summary of the results embodied in Volume I of the *Annals of the Astrophysical Observatory of the Smithsonian Institution.* As illustrating the principal feature of the work, a map was shown of the solar spectrum, only a small part of which, on the left, was the visible spectrum known to Sir ISAAC NEWTON. This was the familiar colored spectrum. The remainder consisted of the extended range of the solar energy invisible to the eye, but which by the researches of Professor LANGLEY was now mapped with the variations of energy shown by curves.

The visible spectrum, from a little beyond the violet, at a wave-length of somewhat less than $0.4\,\mu$, down to the extreme red, which is considered to terminate at the almost invisible line A, whose wave-lenghth is $0.7\,\mu$, has been the seat of prolonged spectroscopic investigation. On a scale of the actual wave-length of light, where the unit of measurement (1 μ) is one one-thousandth of a millimeter, the length of the visible spectrum is 0.36 μ. This prominence of the visible spectrum is due partly to the reason that it is visible, and partly to the fact that the ordinary prism gives an immensely extended linear depiction of the really small amount of energy in this visible part. The region beyond the violet has also received undue attention from the fact that the salts of silver used in photography are extremely sensitive to the short wave-length rays of this portion, although this portion is lacking in energy.

On the map shown, a scale had to be adopted for the spectrum, which has really no positive dimension, being extended at one end or the other, according to the use of the prism or grating employed in producing it. The scale used was such that the infra-red portion of the spectrum, as given by a rock-salt prism, was correct. The visible and ultra-violet given was not exact; for on the prismatic scale it would have taken nearly 100 feet of map to depict, although the ultra-violet really contains much less than one one-hundreth part of the total solar energy, and the visible spectrum but about one fifth. The only law which governs is that the amount of energy in any region of the spectrum, such as that in any color, or between any two specified limits, is a definite quantity fixed by facts independent of our choice, such as the nature of the radiant body or the absorption which the ray has undergone.

Everything in linear presentation, then, depends on the scale adopted. If the lengths be proportional to the energies, the familiar prismatic representation enormously exaggerates the importance of the visible and still more of the ultra-violet region, and similarly the grating spectrum exaggerates that of the infra-red region. On the adopted scale, the visible spectrum had been drawn on the average dispersion of the infra-red.

Of the invisible region beyond the infra-red, nothing was known until 1800, when Sir WILLIAM HERSCHEL found heat there with a thermometer, although this region contains four fifths of the solar energy. Sir JOHN HERSCHEL determined that the heat was not continuous; but it was not until 1871, when LEMANSKY made a drawing of the energy-curve (which, being without scale, is indeterminate), that much was known regarding this region. Three depressions are shown in his curve, indicating lapses of heat in the infra-red. They probably indicate something near to a wave-length of 1 μ. It was this drawing that first interested Professor LANGLEY in the subject.

Prior to 1885 the true wave-lengths were imperfectly known, but were then determined by Professor LANGLEY as far as the end of what he has called the "New Spectrum," at a wave-length of 5.3 μ. After this the next important addition to the subject was made by Captain ABNEY, who gave the photographic spectrum down to 1.1 μ.

The predecessors of Professor LANGLEY had worked with the thermopile, which was insufficient in the feeble heat of the grating-spectrum for good results. This led to his invention of the bolometer, about 1880. The basic idea in this instrument is the formation of a Wheatstone bridge. The variation in conductivity of one arm of the bridge, due to a variation in temperature, while the other arm of the bridge is of a constant temperature, can be measured by a galvanometer. As constructed, the two arms of the bridge are formed by two platinum tapes, one exposed to the heat and the other screened. The width of tape in some bolometers is one two-hundred-and-fiftieth of an inch and its thickness but one tenth of its width. With the improvements introduced in the attending galvanometer by Mr. ABBOTT, it is now possible to register changes in temperature of one one-hundred-millionth of a degree, with an error of less than two one-hundredths of one per cent.

With this sensitive instrument it is possible to locate the invisible lines with an accuracy equal to that of refined astronomical measurements. The action of the bolometer can be compared to an eye that sees in the dark. The solar energy is everywhere the same, and is "light" or "heat" only in accordance with the organ that interprets it. Hence lines like the dark Fraunhofer lines in the visible spectra appear to the bolometer as cold bands, and this hairlike strip of platinum is moved along in the invisible part of the spectrum till the galvanometer indicates the all but infinitesimal change of temperature caused by its contact with such a "cold band."

The first method of observation was extremely slow and tedious, as it required hundreds of observations by three persons to determine with appropriate accuracy the position in wave-length of one invisible line. It took two years to map about twenty such lines, and it was possible that a thousand lines existed.

After twelve years of experimenting, an automatic apparatus has been devised which registers in an hour the lines which would have taken half a century to register by the first method.

Briefly, the method is this: A great rock-salt prism (for a glass one would not transmit these lower rays, nor could they easily be detected in the overlapping spectra of the grating) is obtained of such purity and accuracy of figure, and so well sheltered from moisture, that its clearness and its indications compare favorably, even in the visible spectrum, with those of the most perfect prism of glass, with the additional advantage that it is permeable to the extreme infra-red rays in question. This prism rests on a large azimuth-circle turned by clockwork of the extremest precision, which causes the spectrum to move slowly along, and in one minute of time, for example, to move exactly one minute of arc of its length before the strip of the bolometer, bringing this successively in contact with one invisible line and another. Since what is blackness to the eye is cold to the bolometer, the contact of the black lines chills the strip and increases the electric current. The bolometer is connected by a cable with the galvanometer, whose consequent swing to the right or the left is photographically registered on a plate which the same clockwork causes to move synchronously and uniformly up and down by exactly one centimeter of space for the corresponding minute. By this means the energy-curve of an invisible region, which directly is wholly inaccessible to photography, is photographed upon the plate.

The number of lines in the infra-red spectrum is over seven hundred, and exceeds the number of visible ones in Kirchoff and Bunsen's charts.

In this way the spectrum of solar energy, which has been discovered by the French observers to extend to $1.8\,\mu$, and to which Dr. JOHN DRAPER had set, from theoretical considerations, a limit of a wave-length of $1\,\mu$, has now been discovered and mapped by Professor LANGLEY to a wave-length of $5.3\,\mu$. The region between $1.8\,\mu$ and $5.3\,\mu$ he has termed the "New Spectrum."

One result obtained by these investigations is that, under similar conditions as to altitude and atmosphere, the amount of solar energy varied with the season. Since all life on the Earth depends for its existence on the Sun's energy, it follows that by this means some record might be made of varying solar energy and predictions made of the character of the seasons, and a consequent benefit secured therefrom for humanity. J. D. G.

Continuing the plan inaugurated two years ago, letters were recently sent to the directors of the chief observatories of the Pacific Coast, asking for a statement of the work accomplished during 1901. From the answers received the following accounts have been written:—

Chabot Observatory. — Mr. Burckhalter writes as follows:—

"In answer to the request of the Committee on Publication, I have very little to report of value in the way of original work for the past year. The observatory was given to the Board of Education of Oakland for popular instruction to the public and schools, etc., and, as the observavatory has always been exceedingly popular, the assistant in charge also being required to give a half-day to school-work, scarcely any time is left for original work. All my spare time the past year was taken up in supervising and devising certain parts of the new Assembly Hall just added to the observatory, for which I was held responsible"

International Latitude Observatory, — Dr. Schlesinger's report of the work accomplished at this observatory is as follows:—

"The programme of the International Geodetic Association for Observing Variations of Latitude has been continued without modification at this station, as well as at the five others, throughout 1901. Below is given a summary of the observations made here during the year.

"I. *Observations for latitude proper.*— The following table gives the number of nights and the number of pairs observed in each month:—

1901.	January	14 nights	123 pairs.
	February	10 "	123 "
	March	18 "	153 "
	April	17 "	169 "
	May	17 "	167 "
	June	15 "	187 "
	July	14 "	170 "
	August	15 "	192 "
	September	13 "	146 "
	October	15 "	187 "
	November	12 "	135 "
	December	15 "	163 "
	Totals	175 nights	1,915 pairs.

"II. *Observations for the control of the position of the instrument.* —Owing to the admirable stability of the zenith-telescope and of the meridian-marks, these observations were made only once in about two months. No appreciable error in the latitude would have been incurred if such observations had been omitted altogether during the year.

"III. *Observations for values of the level-spaces.* — One series for this purpose was made during the summer.

"IV. *Observations for micrometer-value.* — The *Pleiades* were observed on every possible occasion during January. One elongation of *Polaris* was observed for the same purpose.

"V. *Observations for screw-errors.* — The *periodic* errors of the micrometer-screw are being examined by the same method as that used for the *progressive* errors. This method is described on other pages of this number.

"No definitive reduction of the observations at the six latitude stations has yet been published. A preliminary discussion including all observations up to January, 1901, will be found in the *Astronomische Nachrichten*, No. 3734."

LICK OBSERVATORY. — Owing to his absence in the East to attend the meeting of the Astronomical and Astrophysical Society of America, Director CAMPBELL finds it impossible to prepare a report for this number of the *Publications.*

MOUNT LOWE OBSERVATORY. — Professor EDGAR L. LARKIN'S account of the work accomplished at this observatory is as follows:—

"The writer assumed directorship of this observatory on January 1, 1901. The year has been one of confusion in building, painting, and putting in electric lights, so that extensive observations have not been made. A new science hall has been added to the building — mostly for spectroscopic and other optical work — and a new covering put on the dome.

OBSERVATIONS, 1901.

January 10th	GIACOBINI'S comet.
February 25th	The new star in *Perseus.*
May 17th and 18th . .	The Australian comet.
August 14th	ENCKE'S comet.
November 15th	The Leonid meteors — 661 recorded.
November 27th	Conjunction *Jupiter* and *Saturn.*
Since July	The sodium lines.
During the year . . .	The stellar floor.
The year	Standard thermometer, barometer, and rain-gauge.

"Since the Brashear spectroscope was mounted in its new room in July, a preliminary study has been made of the two sodium lines and adjacent regions. The heliostat was a home-made affair, bad beyond comparison. A new one of perfect workmanship is now on the way from BRASHEAR. The spectrum has been examined often at precise instants of sunrise, when the Sun's limb is rising over bare rock on the summits of the mountains, or emerging from thickets of manzanita shrubs; also at instants of sunset both in the sea and over rocks capping the coast ranges. No interpretation is offered. The dust question is looming up in spectroscopy; and the silicious sheets sent hither by the Mojave Desert make havoc with solar rays and quench their waves. Often eleven lines are seen between D_1 and D_2, from five to fifty between D_2 and D_3, and as many more on the opposite side of D_1 to an equal distance. These phenomena must be studied a year after the arrival of the new heliostat before anything of value is derived from the research, if at all. The spectrum of *Nova Persei* secured here on February 25th is well represented by figure 1, following page 232, No. 81, these *Publications*."

Mr. LARKIN has also interested himself in a study of the sky on dark clear nights. The mountain station has a particular advantage for such work as this, as the observer is usually far above the dust-laden atmosphere of the lower levels. Mr. LARKIN'S report of the work is unfortunately too long to reproduce here, but the nature of the results obtained is indicated by the following sentence:—

> "The entire background of *Orion*, as seen here, is either a complete nebula or an incredible number of excessively minute stellar points. After a rain and on the clearest, darkest nights, *Orion* is always bound in white, while at the same time other portions of the celestial vault are jet black between the stars."

STUDENTS' OBSERVATORY.—The special announcement to students mentioned in the report of last year has been printed and distributed. It gives a description of the instrumental equipment of the Lick and Students' observatories and a comprehensive outline of the courses of study, both graduate and undergraduate, and special lines of work that the students may take up The student may specialize along one of three lines, the nature of which is sufficiently indicated by the names,—Theoretical Astronomy and Celestial Mechanics; Astrophysics; Geodesy. During the first term of 1901 the total enrollment of students in astronomical courses was 92, and during the second term 119. Several special lines of work were carried on during 1901. Professor LEUSCHNER'S work upon the orbit of the faint asteroid discovered by the late Professor KEELER with the Crossley reflector has led to a new method of determining orbits from three observations. The work is to be published in the Lick Observatory Bulletins under the title of "A Short and General Method of Determining Orbits from Three Observations." Professor LEUSCHNER and Miss HOBE have also published in this same connection "Elements of Asteroid 1900 G. A. and Ephemeris for the Opposition of 1901–1902." Both of these papers were presented in the recent meeting of the Astronomical and Astrophysical Society of America. The new method has been applied by Mr. R. A. CURTISS and Mr. C. G. DALL to Comet *c* 1900, and is now being tested by application to the South Comet 1901 by Mrs. L. S. RICHARDSON and Mr. C. A. G. WEYMOUTH. Dr. TOWNLEY has been studying the light variations of *Nova Persei*, and a portion of the results obtained has already been printed in these *Publications*. Mr. J. D. MADDRILL, assistant in the observatory, has observed the magnitudes of *Nova Persei* and micrometer positions of asteroids. Dr. A. F. GILLIHAN, a special student, has also made micrometer observations of asteroids. Dr. R. T. CRAWFORD and Dr. F. E. ROSS are engaged for the Watson Trustees in computing the general perturbations of the Watson asteroids.

UNITED STATES COAST AND GEODETIC SURVEY OBSERVATORY.—This observatory, situated in the Presidio Reservation, San Francisco, and provided with a transit and a zenith-telescope, is used as a longitude base for the determination of new stations by telegraphic time-signals and for practice of observers. Captain AUG. F. ROGERS, Assistant in Coast Survey, and in charge of the observatory, writes, however, that no new determinations were made during 1901.